Year: 2015

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DOI: https://doi.org/10.1007/s00330-014-3403-7

Originally published at:
Dietrich, Tobias Johannes; Moor, Beat K; Puskas, Gabor J; Pfirrmann, Christian W A; Hodler, Juerg; Peterson, Cynthia K (2015). Is the lateral extension of the acromion related to the outcome of shoulder injections? European Radiology, 25(1):267-273.
DOI: https://doi.org/10.1007/s00330-014-3403-7

Eur Radiol (2015) 25:267–273
DOI 10.1007/s00330-014-3403-7

MUSCULOSKELETAL

Is the lateral extension of the acromion related to the outcome of shoulder injections?

Tobias Johannes Dietrich · Beat K. Moor · Gabor J. Puskas · Christian W. A. Pfirrmann · Juerg Hodler · Cynthia K. Peterson

Received: 25 June 2014 / Accepted: 14 August 2014 / Published online: 29 August 2014

Abstract

Objective To assess patients' outcomes after subacromial or glenohumeral injections based on the degree of lateral extension of the acromion.

Methods 307 patients were prospectively included after therapeutic fluoroscopy-guided subacromial (n=148) or glenohumeral (n=159) injections with anaesthetic and long-acting corticosteroids. Pre- and post-injection outcomes at 1 week and 1 month were obtained using the 11-point numerical rating scale (NRS) for pain. Lateral extension of the acromion was quantified and categorized by the critical shoulder angle (CSA) and the acromion index (AI) on anteroposterior conventional radiographs.

Results Patients' outcomes at 1 week and 1 month were significantly improved (p<0.001) compared to baseline for subacromial and glenohumeral injection patients. Patients with a CSA <35° showed significantly higher pain reduction 1 month after subacromial injection compared to patients with a CSA >35° (4.2±2.6 vs. 3.2±3.0, p=0.04). A significant difference in the 1-month NRS change in pain scores is noted for smaller AIs after subacromial injection (4.3±2.8 vs. 2.6±2.9; p=0.01). No significant association was noted between clinical outcome and the lateral extension of the acromion after glenohumeral joint injections.

Conclusions A short lateral extension of the acromion was associated with better clinical outcomes in subacromial injection patients but not in glenohumeral injection patients.

Key Points

- *Patients' outcomes at 1 month improved significantly compared to baseline for subacromial injections*
- *Patients' outcomes at 1 month improved significantly compared to baseline for glenohumeral injections*
- *Short acromial lateralization was associated with better clinical outcome after subacromial injection*
- *The acromial lateralization was not associated with clinical outcome after glenohumeral injection*

Keywords Conventional radiograph · Shoulder · Subacromial impingement syndrome · Triamcinolone · Intra-articular injection

Abbreviations and Acronyms

NRS	Numerical rating scale
CSA	Critical shoulder angle
AI	Acromion index
ICC	Intraclass correlation coefficient
SD	Standard deviation

Introduction

A variety of shoulder pathologies such as osteoarthritis, adhesive capsulitis (frozen shoulder), SLAP lesion (superior labral tear from anterior to posterior), shoulder pain from unknown aetiology, or impingement syndrome are frequently treated by injections with local anaesthetics and corticosteroids into the subacromial bursa and/or the glenohumeral joint [1–6]. However, the research evidence for shoulder pain management with imaging-guided therapeutic joint injections for conditions other than inflammatory arthropathies has been shown to be limited [5, 7]. The reason for this lack of strong research evidence supporting the effectiveness of these

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injections may be that they are often used without a specific diagnosis or cause for the symptoms.

A large lateral extension of the acromion, as noted on true anteroposterior radiographs of the shoulder made with the arm in neutral position, has been shown to be associated with rotator cuff tears [8, 9], whereas a short lateral extension of the acromion with an inferiorly inclined glenoid has been related to glenohumeral osteoarthritis [9]. Consequently, the lateral extension of the acromion is associated with impingement-related disorders as well as intra-articular pathologies such as osteoarthritis. According to Neer's article from 1972, shoulder impingement includes the diagnoses of subacromial bursitis, tendinopathy, and partial and full-thickness tearing of the rotator cuff [10]. Thus this relatively simple imaging evaluation [9] may also be relevant in determining which imaging-guided therapeutic injection procedure would be more appropriate based on patient responses to these treatments. Shoulder impingement patients may be managed by subacromial injections [2, 3], whereas symptoms arising from the glenohumeral joint may be treated by intra-articular injection [6, 11–13].

It was hypothesized that different extents of acromial coverage might influence patients' outcomes after therapeutic subacromial or glenohumeral injections using local anaesthetics and long-acting corticosteroids.

Thus the purpose of this study was to compare patients' outcomes after subacromial or glenohumeral injections based on measurements and categorization of the lateral extension of the acromion.

Materials and methods

Study design and population

This was a prospective outcome study of consecutive patients from two different patient cohorts. One group had imaging-guided therapeutic subacromial injections and the other group had imaging-guided therapeutic glenohumeral joint injections. Ethical approval was obtained from the Institutional and Cantonal Review Boards for this study. Patients provided signed informed consent before the therapeutic fluoroscopy-guided injection with long-acting corticosteroids.

Patients with previous surgery of the ipsilateral shoulder and patients with contrast leakage into the glenohumeral joint on the subacromial bursogram or in the subacromial bursa on the shoulder arthrograms as proof of a full thickness tear of the rotator cuff or on available magnetic resonance imagining (MRI) were excluded [14–16]. Patients with multiple injections into the same shoulder such as subacromial, glenohumeral, and acromioclavicular injections within 1 month were also excluded. In total, 100 patients in the subacromial injection group and 88 patients in the glenohumeral injection group were excluded. A total of 307 patients with complete outcome-based questionnaire data and available conventional radiographs were prospectively included in the present study after applying the exclusion criteria. 148 patients were included after receiving subacromial injections and 159 patients after receiving glenohumeral infiltrations between January 2010 and March 2013.

Injection procedure

Fellowship-trained shoulder surgeons from the orthopaedic surgery department at our institution obtained patients' medical histories and physical examinations. Subacromial shoulder impingement was the indication for subacromial injections. Shoulder impingement was diagnosed by Neer's sign, Hawkin's test, and the painful arc test [10, 17, 18]. Patients with clinical symptoms for an intra-articular source of pain such as adhesive capsulitis (frozen shoulder), biceps-related disorders (tendinopathy and SLAP lesion [superior labral tear from anterior to posterior]), or osteoarthritis of the glenohumeral joint were referred for glenohumeral joint injection [19–21]. All therapeutic subacromial or glenohumeral injections were performed under fluoroscopy guidance using sterile conditions by one of five fellowship-trained musculoskeletal radiologists or by one of three board-certified radiologists during their musculoskeletal radiology fellowship programme. The correct location of the needle tip was confirmed by iodinated contrast agent (iopamidol, 200 mg of iodine/ ml; Bracco, Milan, Italy) and documented by a conventional radiograph. Anterior portals were used for both the subacromial (Fig. 1) and glenohumeral injections (Fig. 2). The needle tip was directed inferolaterally to the undersurface of the acromion process followed by a subacromial bursogram for the subacromial injection (Fig. 1). The needle tip was directed towards the cartilage surface of the humeral head superomedial followed by a conventional arthrogram for the glenohumeral injection (Fig. 2). Subsequently long-acting corticosteroids (40 mg of triamcinolone acetonide; Helvepharm AG,

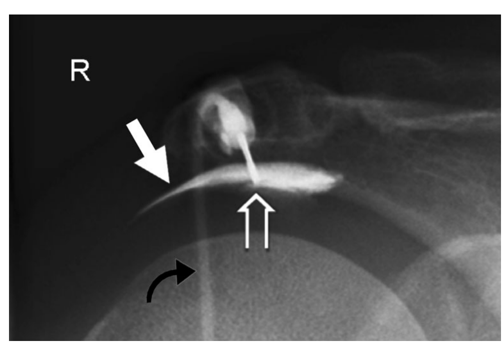

Fig. 1 A 53-year-old woman with subacromial shoulder impingement underwent subacromial infiltration. The radiograph demonstrates the correct position of the injection needle tip (open white arrow) and typical subacromial contrast agent distribution (bold white arrow). The curved black arrow indicates the connection tube between the syringe (not shown) and the injection needle

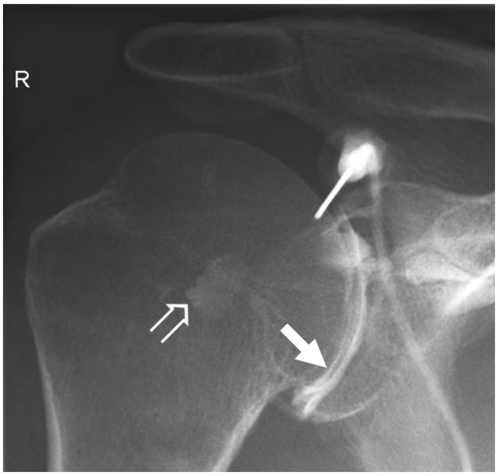

Fig. 2 A 54-year-old man with partial articular-sided supraspinatus tendon avulsion (PASTA) lesion underwent glenohumeral infiltration. Radiograph shows the contrast agent distribution within the glenohumeral joint space (bold white arrow) and the posterior joint recess (open white arrow)

Frauenfeld, Switzerland) and 2–5 ml of local anaesthetic (lidocaine hydrochloride 2 %; Sintetica SA, Mendrisio, Switzerland) were injected.

Baseline data and outcome measures

Patients' outcomes from the subacromial and glenohumeral injections were assessed by asking all patients to complete the 11-point numerical rating scale (NRS) for pain, where 0 indicates no pain and 10 indicates the worst pain imaginable. The NRS pain levels were obtained before the injection, at 1 week, and at 1 month post-injection.

Conventional radiographs

Conventional radiographs of the shoulder consisted of the anteroposterior (AP), axial, and Neer's projections, as this is the standard procedure in our institution. Anteroposterior views served exclusively in the present investigation for the measurements and were acquired with a digital radiography system (Ysio, Siemens Healthcare, Erlangen, Germany) and the following exposure parameters: detector area of 35×43 cm; neutrally rotated arm; 20° craniocaudal angulation of the x-ray beam; patients in the standing position; no use of a grid; typical value of tube voltage, 61.5 kVp; automatic exposure for tube current (typical value: 50 mAs); detector-to-tube distance, 150 cm.

Quantification of lateral extension of the acromion process on radiographs

The lateral extension of the acromion was quantified on the radiographs using two different measurement methods. One was the so-called critical shoulder angle (CSA) [9] and the other was the acromion index (AI) [8]. The CSA was measured as the angle between the glenoid plane and the line from the inferior osseous margin of the glenoid plane and the lateral aspect of the acromion [9] (Figs. 3a and 4a). The measurements were then assigned to one of two categories: <35° and >35°. The AI [8] was determined as the ratio of the distance from the glenoid plane to the acromion process (GA) and the distance from the glenoid plane to the lateral aspect of the humeral head (GH): AI = GA/GH (Figs. 3b and 4b) [8]. The AI numerical values were assigned to one of three categories: <0.64, 0.64 – 0.73, and >0.73. The larger the lateral extension of the acromion, the higher the critical shoulder angle and the AI [8, 9].

One staff radiologist (TJD, observer 1) performed both the AI and critical shoulder angle measurements for all patients in both injection groups. One of two staff orthopaedic surgeons measured the critical shoulder angle (BKM, observer 2) or the

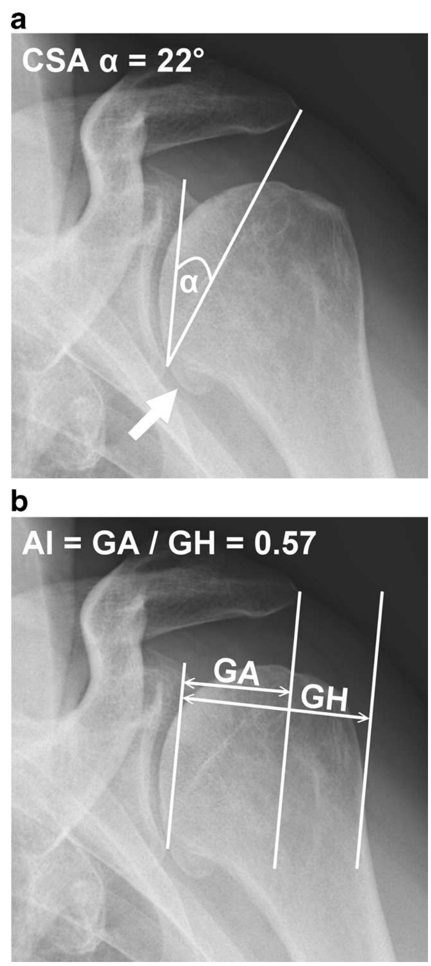

Fig. 3 A 55-year-old man with osteophytes (**a**, bold white arrow) and moderate radiographic joint space narrowing inferiorly indicative of osteoarthritis of the glenohumeral joint. The critical shoulder angle α (CSA, A) of 22° and the acromion index (AI) of 0.57 (**b**, AI = ratio between distance GA and GH) represent the short lateral extension of the acromion process, which has been related to osteoarthritis of the glenohumeral joint

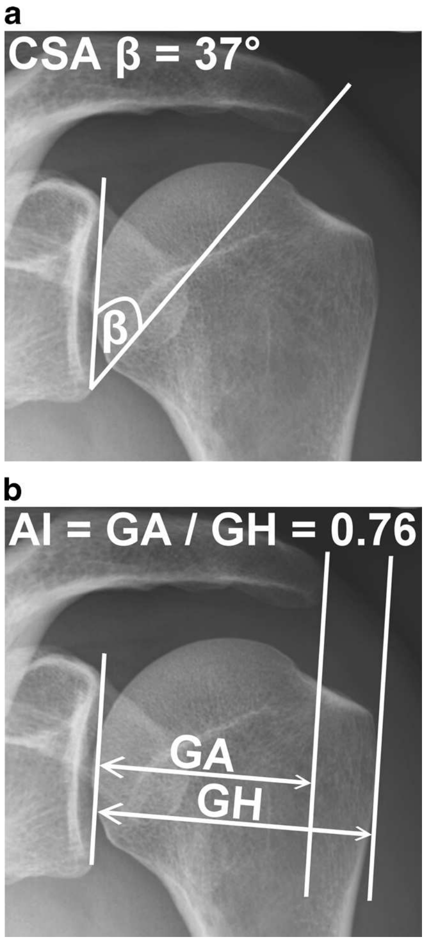

Fig. 4 A 40-year-old man with subacromial shoulder impingement. The critical shoulder angle β (CSA, **a**) of 37° and the acromion index (AI) of 0.76 (**b**, AI = ratio between distance GA and GH) are indicative of a large lateral extension of the acromion process, which has been shown to be associated with rotator cuff tears

AI (GJP, observer 3) to assess the interobserver agreement. Measurements were acquired on a picture archiving and communication system (PACS) workstation (AGFA Impax 6.4.0.4551, Agfa HealthCare, Mortsel, Belgium).

Statistical analysis

The baseline to 1 week and baseline to 1 month NRS change in pain scores were calculated and compared for the measurement categories using the *t*-test for the CSA categories and the ANOVA test for the AI categories. A p-value <0.05 was considered to indicate a statistically significant difference between the groups.

Interobserver reliability of the measurement procedures was assessed using the Intraclass correlation coefficient for the numerical values and the Kappa statistic for the two measurement procedures. A software package was used for the calculations (SPSS Statistics for Windows Version 21.0, IBM Corp, Armonk, NY, USA).

Results

General outcomes for subacromial and glenohumeral joint injections

Table 1 lists the baseline numerical rating scale for pain scores and patients' outcome at 1 week and 1 month. Patients' baseline pain assessed by the numerical rating scale for pain was 6.4±1.9 for subacromial injection patients and 6.2±2.2 for glenohumeral injection patients. Patients' pain at 1 week and 1 month was significantly lower (p<0.001) compared to baseline for both study populations, the subacromial and the glenohumeral injection groups. The NRS for pain values at 1 week were 2.9±2.3 (NRS Change Score: 3.5±2.6) for the subacromial injection group and 3.2±2.3 (NRS Change Score: 2.9±2.4) for the glenohumeral injection group. The corresponding NRS values at 1 month were 2.6±2.5 (NRS Change Score: 3.8±2.8) for the subacromial injection group and 2.7±2.3 (NRS Change Score: 3.4±2.6) for the glenohumeral injection group.

Lateral extension of the acromion on radiographs

The mean CSA in patients having subacromial infiltrations for observer 1 was 33.6° (SD=3.8) with a range of 23.7–40.4° and for observer 2 it was 33.5° (SD=3.6) with a range of 24.4–39.6°. The mean AI for subacromial infiltration patients as measured by observer 1 was 0.68 (SD=0.07) with a range of 0.50–0.79. For the glenohumeral infiltration group the mean CSA as measured by observer 1 was 32.8° (SD=4.0) with a range of 20.5–44.7° and for observer 3 it was 32.0° (SD=4.2) with a range of 19.0–45.8°. The mean AI was 0.67 (SD=0.07) and a range of 0.43–0.87 for observer 1. The corresponding mean AI for observer 3 was 0.66 (SD=0.08) with a range of 0.41–0.90.

Table 1 Comparison of numerical rating scale (NRS) pain scores and NRS change in pain scores at 1 week and 1 month post-injection for all subacromial injection patients (*n*=148) and all glenohumeral injection patients (*n*=159)

	Subacromial injection (*n*=148)	Glenohumeral injection (*n*=159)
Baseline NRS ± SD	6.4±1.9	6.2±2.2
1 Week NRS ± SD	2.9±2.3*	3.2±2.3*
1 Month NRS ± SD	2.6±2.5*	2.7±2.3*
1 Week NRS change score ± SD	3.5±2.6	2.9±2.4
1 Month NRS change score ± SD	3.8±2.8	3.4±2.6

An asterisk (*) indicates that patients' outcomes improved significantly (p <0.001) at both 1 week and 1 month compared to baseline

Interobserver agreement

Interobserver agreement critical shoulder angle

The inter-rater reliability of measuring the critical shoulder angle as tested using the intraclass correlation coefficient (ICC) was almost perfect with a mean of 0.94 (95 % CI= 0.92–0.96). Similarly the inter-rater reliability of categorizing these measurements as evaluated using the Kappa statistic was also 'almost perfect' with a Kappa value of 0.91.

Interobserver agreement acromion index

The inter-rater reliability of measuring the AI using the ICC was also almost perfect with a mean of 0.96 (95 % CI=0.94–0.97). Assessing the inter-rater reliability of categorizing the AI using the Kappa statistic found substantial agreement with a Kappa value of 0.77.

Subacromial injection outcome for different categorizations of the lateral extension of the acromion

Baseline NRS pain scores for the subacromial injection groups (Tables 2 and 3) revealed no significant differences, either between the two CSA categories or between the three categories of the AI. However, comparing the NRS change scores found a significant difference at 1 month with CSAs of <35° showing significantly more pain reduction (Table 2) after subacromial injection. In addition, a significant difference in the 1-month NRS change scores for the AI is noted, with category 3 patients having the lowest change in pain score while category 2 patients had the highest pain decrease after subacromial injection (Table 3).

Glenohumeral injection outcome for different categorizations of the lateral extension of the acromion

There were no statistically significant differences after glenohumeral injection either between the two CSA categories or between the three AI categories for pre-injection baseline or the follow-up NRS change in pain scores (Tables 2 and 3).

Discussion

The purpose of the present study was to compare specific findings on routine shoulder radiographs with outcomes from imaging-guided therapeutic subacromial and glenohumeral injections in an attempt to better predict which patients may respond more favourably to this treatment and to explore how anatomical variations may contribute to specific clinical symptoms. The results from this study support a relationship between anatomical differences and outcomes from these injections, particularly for patients having subacromial therapeutic injections. Specifically, patients with a short lateral extension of the acromion on anteroposterior radiographs of the shoulder showed a significantly higher pain reduction after subacromial injection when compared to patients with a large lateral extension of the acromion. The fact that the inter-rater reliability of the CSA and AI measurements was so high is reassuring, showing that these two measurements are easily reproducible.

The hypothesis as to why subacromial injection patients have better outcomes with the shorter acromion process is that patients with a larger lateral extension of the acromion (CSA of >35°, AI of >0.73) are more prone to rotator cuff tears due to the relative length of the acromion process impinging upon the structures inferiorly [8, 9]. Prior to the presence of a tear, the patient would likely experience clinical signs of impingement and therefore more likely be referred for a subacromial injection rather than a glenohumeral injection.

One recent publication [22] reported specific abnormalities detected on routine radiographs that are associated with better outcome from therapeutic subacromial injections in a smaller study population. However, the CSA was not assessed in that study. These types of studies comparing treatment outcomes with specific imaging findings can help referring clinicians in advising patients as to what to expect from various interventions,

Table 2 Comparison of baseline numerical rating scale (NRS) pain scores and NRS change in pain scores at 1 week and 1 month post-injection between the two categories of the critical shoulder angle (CSA) for subacromial injection patients and glenohumeral injection patients

	Subacromial injection			Glenohumeral injection		
	CSA Cat. 1 (<35°) (*n*=96)	CSA Cat. 2 (≥35°) (*n*=52)	p value	CSA Cat. 1 (<35°) (*n*=123)	CSA Cat. 2 (≥35°) (*n*=36)	p value
Baseline NRS ± SD	6.3±1.8	6.5±2.1	0.50	6.2±2.2	6.0±1.9	0.57
1 Week NRS change score ± SD	3.7±2.6	3.2±2.5	0.25	2.8±2.5	3.3±1.9	0.34
1 Month NRS change score ± SD	4.2±2.6	3.2±3.0	**0.04**	3.3±2.7	3.6±2.4	0.55

SD standard deviation

Table 3 Comparison of baseline numerical rating scale (NRS) pain scores and NRS change in pain scores at 1 week and 1 month post-injection between the three categories of the Acromial Index (AI) for subacromial injection patients and glenohumeral injection patients

	Subacromial injection				Glenohumeral injection			
	AI Cat 1 (<0.64) (*n*=45)	AI Cat 2 (0.64-0.73) (*n*=70)	AI Cat 3 (>0.73) (*n*=33)	p value	AI Cat 1 (<0.64) (*n*=68)	AI Cat 2 (0.64-0.73) (*n*=62)	AI Cat 3 (>0.73) (*n*=29)	p value
Baseline NRS ± SD	6.1±1.8	6.5±2.1	6.6±1.7	0.42	5.9±2.2	6.5±2.2	6.0±1.9	0.28
1 Week NRS change score ± SD	3.5±2.7	3.9±2.5	2.7±2.5	0.08	2.7±2.7	3.0±2.3	3.3±2.0	0.28
1 Month NRS change score ± SD	3.9±2.6	4.3±2.8	2.6±2.9	**0.01**	3.2±2.7	3.4±2.7	3.6±2.4	0.56

SD standard deviation

based on their particular imaging findings. Individual quantitative anatomy may be related to biomechanics that induce specific types of degenerative joint disorders such as glenohumeral osteoarthritis or rotator cuff tears [9]. An upward facing plane of the glenoid, the so-called glenoid inclination on anteroposterior radiographs, was associated with rotator cuff tears [23] and superior humeral head migration [24]. It was hypothesized that superior humeral head migration may cause impingement of the supraspinatus tendon [24]. A large lateral extension of the acromion was associated with full-thickness tears of the supraspinatus tendon [8, 9]. Nyfeller et al. [8] speculated that a larger lateral extension of the acromion might increase the ascending deltoid muscle force vector to the humerus as a potential aetiology of subacromial impingement and degenerative changes of the supraspinatus tendon. A smaller lateral extension of the acromion might increase the compressive force to the humeral head against the glenoid cavity, thus a smaller lateral extension might predispose to degenerative changes of the glenohumeral joint [8]. The CSA measurement covers two factors associated with rotator cuff tears, the large lateral extension of the acromion as well as the increased inclination of the glenoid [9].

In contrast to the CSA, the AI measurement does not integrate the inclination of the glenoid [9]. In addition, osteoarthritis misleadingly increases the AI due to the flattening of the humeral head and narrowing of the radiographic joint space [8, 9]. A short lateral extension of the acromion assessed by the critical shoulder angle as well as the AI was associated with a significantly better outcome after subacromial injection. However, no difference was found after glenohumeral injections in the present study.

Separate measurements of the lateral extension of the acromion by the AI as well as the glenoid inclination did not reveal significant differences in clinical improvement after image-guided subacromial injections in a previous study including 98 patients [22]. Nevertheless, the published data in that study demonstrated a trend for better clinical outcomes in patients with a smaller lateral extension of the acromion [22]. However, patients with different glenoid inclinations in that same study revealed very similar clinical outcomes [22], and the authors used a robust and reproducible measurement method for the glenoid inclination measurements [22, 25]. The authors [22] also did not find a significant difference in clinical improvement after subacromial injections between patients with and without an os acromiale, the various acromial shapes according to Bigliani classification, a lateral down-sloping acromion, reduced acromiohumeral distance, anterior or lateral acromial spurs and osteophytes of the glenohumeral and acromioclavicular joint on conventional radiographs.

In general, the outcomes for glenohumeral injection patients in the categories of the two measurements were not significant or perhaps not as interesting compared to those from the subacromial injection patients; however, the glenohumeral injection patients may serve as a control group for the subacromial injection patients in the present investigation. Additional imaging findings, including the presence or absence and severity of glenohumeral osteoarthritis, compared to outcomes should be investigated to test the hypothesis that patients with a critical shoulder angle <30° are more likely to have osteoarthritis.

Limitations

One limitation of this study is that the presence of various degrees of other shoulder impingement-related radiological parameters, osteoarthritis, adhesive capsulitis (frozen shoulder), SLAP lesion, other sources of shoulder pain, patients' age, and adjunctive therapy such as physiotherapy or NSAIDs were not analysed. Only 1-month outcomes were collected rather than longer term outcome data. The pharmacokinetics of triamcinolone after intra-articular and intramuscular administration have shown that absorption of triamcinolone from the injection site is complete after a period of 2–3 weeks with a similar duration of action [19, 26–28]. Other factors as discussed above might have a stronger influence on outcome at a longer follow-up period than 1 month. However, the purpose of the study was to evaluate the clinical outcomes after subacromial and glenohumeral injections for different extents of acromial coverage using a simple, highly reproducible tool on conventional radiographs [9].

Conclusions

Our hypothesis that different extents of acromial coverage might influence patients' outcome after therapeutic subacromial or glenohumeral injections was disproved for glenohumeral injections and confirmed for subacromial injections.

A short lateral extension of the acromion was associated with a better clinical outcome in subacromial injection patients but not in glenohumeral injection patients.

Acknowledgements The scientific guarantor of this publication is Cynthia K. Peterson DC, M.Med.Ed. The authors of this manuscript declare no relationships with any companies whose products or services may be related to the subject matter of the article. This study received funding by a grant from the Vontobel-Stiftung, Toedistrasse 17, 8002 Zurich, Switzerland. One of the authors has significant statistical expertise: Cynthia K. Peterson DC, M.Med.Ed. Institutional Review Board approval was obtained. Written informed consent was obtained from all patients in this study. Some study subjects or cohorts have been previously reported in AJR 2013;201:865-871 and BMC Musculoskeletal Disorders 2012, 13:241. There should be no potential conflict between the two previous publications and this current publication regarding redundant publication or so-called self-plagiarism. The present data, images, and manuscript are unique. Methodology: prospective, observational, performed at one institution.

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